



**ROV INVESTIGATIONS OF THE DKM *U-166*
SHIPWRECK SITE TO DOCUMENT THE
ARCHAEOLOGICAL AND BIOLOGICAL ASPECTS OF
THE WRECK SITE**

SEMI-ANNUAL PERFORMANCE REPORT

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Prepared for the NOAA Office of Ocean Exploration

by



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A handwritten signature in black ink that reads "Daniel J. Warren".

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STUDY TITLE: ROV Investigations of the DKM *U-166* Shipwreck Site to document the Archaeological and Biological Aspects of the Wreck Site

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BACKGROUND: In America during the early months of 1942 the war seemed far away, but in reality an ominous threat, Hitler's U-boats, lurked in the waters off the Eastern and Gulf Coasts. Following America's entry into World War II after Japan's attack on Pearl Harbor, Hitler extended U-boat attacks to the shores of America just as Germany did during World War I. This time, however, the U-boats were not limited to operations on the America's East Coast. U-boat captains would also strike deeply into America's backyard, the Gulf of Mexico.

Over roughly a year's time, beginning in May 1942, twenty-four German U-boats entered the Gulf of Mexico. Seventeen of these U-boats sank fifty-six merchant ships and damaged several others (Wiggins, 1995:passim). The DKM *U-166*, under the command of Hans-Günther Kühlmann was one such boat. The DKM *U-166* entered the Gulf of Mexico in early July 1942 and proceeded on a mission to lay mines off the mouth of the Mississippi River. On July 27, 1942 Kühlmann radioed German Naval Command reporting completion of mine laying activities and that he was proceeding to hunt shipping (War Diary, 1942: 36,53,92;). It would be the final message from DKM *U-166*.

On July 30, 1942 the passenger freighter S.S. *Robert E. Lee* was bound for New Orleans under escort from a newly commissioned patrol craft, *PC-566*. Approximately 45 miles from the Mississippi River's Southwest Pass, a torpedo fired from the DKM *U-166* struck the S.S. *Robert E. Lee's* starboard side. As the freighter began to sink, *PC-566* rushed to attack the submarine. After gaining sonar contact the patrol dropped ten depth charges across the U-boats path as it attempted to dived to a safer depth. An oil slick and the patrol craft's inability to regain sonar contact with DKM *U-166* led *PC-566's* crew to believe the U-boat had fled or been sunk. A Navy review board later ruled it unlikely that *PC-566* sank the U-boat.

Two days later, on August 1, 1942, two U.S Coast Guardsmen, Pilot Henry White and Radio Operator George Boggs, were patrolling in a J4F amphibious aircraft roughly 100 miles south of Houma Louisiana when they spotted a U-boat on the surface. As the U-boat crash-dived towards the safety of deep water, White and Boggs attacked with their only weapon, a single depth charge. White and Boggs reported the depth charge exploded near the submarine and an oil slick appeared on the surface. When they returned to base they were informed the incident was classified. A year later, White and Boggs were told they had destroyed the DKM *U-166* and were decorated for their action .

For the next 59 years history recorded the DKM *U-166* was sank off Louisiana's coast 100 miles south of Houma. Despite the numerous oil gas surveys in the region and expeditions to the area by groups seeking DKM *U-166*, it was never found.

In 1986, Shell Offshore had an oil and gas hazard survey conducted in the Gulf of Mexico's Mississippi Canyon Area. During this survey, conducted by John E. Chance and Associates, two shipwrecks were noted and tentatively identified as the S.S. *Robert E. Lee* and another U-boat casualty, the S.S. *Alcoa Puritan*. No further investigations were carried out to positively identify the vessels.

In January 2001 C & C Technologies, Inc. (C & C) conducted another survey for British Petroleum and Shell International in the Mississippi Canyon Area near the reported location of the S.S. *Robert E. Lee*. This survey was conducted using C & C's new HUGIN 3000 Autonomous Underwater Vehicle (AUV), a completely untethered survey platform. During the January survey a large wreck was detected near the edge of the survey swath. C & C Marine Archaeologists Robert Church and Daniel Warren verified with the Minerals Management Service (MMS) that this was the S.S. *Robert E. Lee*. Because the S.S. *Alcoa Puritan* was known to be in close proximity to the wreck of the S.S. *Robert E. Lee* BP and Shell agreed that additional survey investigation with the HUGIN 3000 AUV be carried out to precisely position any wreckage in relation to the proposed pipeline route.

In March 2001 the additional survey work was completed. When the data was reviewed by C & C's Marine Archaeologists they noted the wreck of the S.S. *Robert E. Lee* and a new area of wreck debris, less than a mile to the east, where the 1986 survey had placed the wreck of the S.S. *Alcoa Puritan*. During the analysis, it became apparent to Church and Warren that the wreckage thought to be the S.S. *Alcoa Puritan* was not consistent with that size and type of freighter. The wreckage was consistent, however, with the dimensions of a Type IXC German U-boat (252 feet in length and 22 feet wide), the same class as the DKM *U-166*.

Church and Warren developed a new hypothesis to explain why the DKM *U-166* was 140 miles east of where history had recorded it lost. This hypothesis proposed the DKM *U-166* was destroyed on July 30, 1942 by Patrol Craft 566's depth charge attack, and Coast Guard aviators White and Boggs bombed a different submarine that escaped. To lend credence to this hypothesis, the reconstructed logs of the DKM *U-171*, the only other U-boat in the area at the time, were examined. These logs stated that around early August 1942 while off the Louisiana Coast the DKM *U-171* was bombed by a "flying boat" (a good description of an amphibious aircraft) but sustained no damage. The attack's exact date could not be determined since the original logbooks were lost when the DKM *U-171* was destroyed by a mine in the Bay of Biscay when returning from its patrol in the Gulf of Mexico.

The hypothesis that the second area of wreckage could be the DKM *U-166* led BP and Shell to sponsor further site specific investigations of the S.S. *Robert E. Lee* and suspected DKM *U-166* sites using the HUGIN 3000 AUV. The results of this data (See Figure No. 1) provided additional support to the DKM *U-166* hypothesis and stressed the need for a final verification of the wreck's identity through visual inspection with a Remotely Operated Vehicle (ROV).

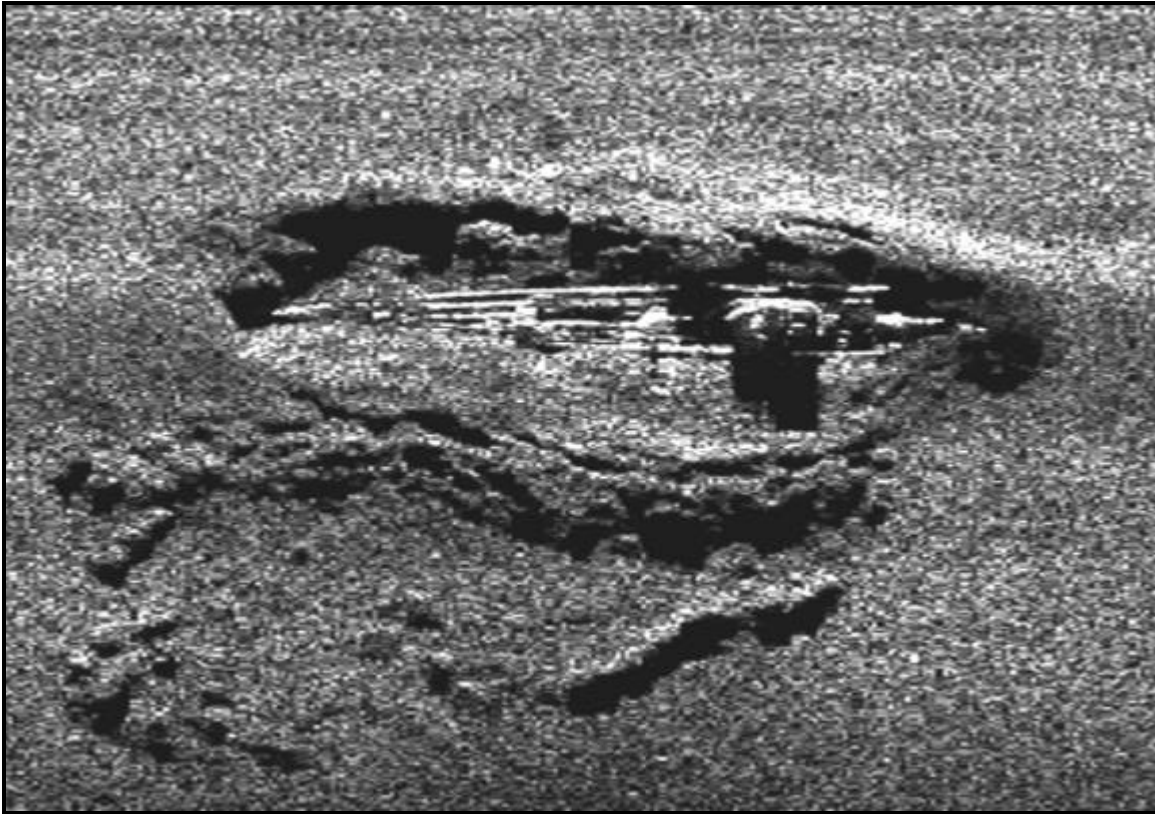


Figure No. 1: HUGIN 3000 High Resolution Side Scan of *U-166* remains, 2001

On May 31 and June 1, 2001 a research team comprised of representatives from BP, Shell, C & C, and the MMS traveled to the Mississippi Canyon Area to determine if the German *U-boat*, DKM *U-166* had actually been located. Using an ROV, the expedition confirmed the DKM *U-166* hypothesis by bringing back the first images in 59 years of the DKM *U-166* as well as its last victim the passenger freighter S.S. *Robert E. Lee*.

The expedition was successful in identifying the long sought after U-boat and its last victim. Unfortunately, the expedition could only carry out cursory examinations of the wreck sites due to the limited availability and capabilities of the ROV used. Time constraints with the ROV allowed only 24 hours (approximately 8 hours of dive time) to investigate both shipwreck sites with less than 4 hours being spent to document the DKM *U-166* site.

Significance of the DKM *U-166*

Hitler's U-boat war along America's East Coasts and in the Gulf of Mexico succeeded in sinking numerous merchant ships during the initial forays. This success, however, was not without cost. Many of the U-boats that conducted attacks along America's coast were sunk, among them the DKM *U-166*. These vessels resting in U.S. waters are recognized war graves and are considered historically significant shipwrecks. Of the U-boats lost in American waters, however, the DKM *U-166* stands out. The DKM *U-166* is significant among the other U-boats because it was the only one lost in the Gulf of Mexico, and because of its unique state of preservation.

Many U-boats lost along America's coasts were sunk in the relatively shallow waters along the Eastern Continental Shelf. Over the past 60 years these U-boats have been repeatedly subjected to the elements, and more recently souvenir hunting sport divers. The result of these depredations, by nature and man, has been the partial destruction of many of these wrecks. This is not the case with the DKM *U-166*. Resting in approximately 5,000 feet of water the wreck has not been subjected to the strong currents, wave action, or storms associated with shallow waters. Its extreme depth has also protected it from being preyed upon by souvenir divers. As a consequence of its location, the DKM *U-166* represents a pristine example of a Type IXC U-boat, notwithstanding the fact that the wreck is in two sections 500 feet apart.

Additionally, the DKM *U-166*'s location in deepwater water has led to rusticle formation. The rusticles are actually microbial communities that live off of the iron on wrecks. These microbial communities have been documented on other deep water shipwrecks including RMS *Titanic* and DKM *Bismarck*. Several groups of these rusticles are visible on the 2001 video of DKM *U-166*, mainly on the damaged part of the bow section. There is a lack of knowledge of the manner in which rusticles can afflict maritime steel structures leading to premature failures. These effects are a combination of embrittlement, corrosion, and losses in tensile strength. Studying the nature of the rusticle growths could have long-term implications for the sustainability of maritime steel structures.

OBJECTIVES: Because of the DKM *U-166*'s historical significance and its unique state of preservation, it was determined that a more detailed study was warranted. The 2003 Field Investigations of the DKM *U-166* wreck site were carried out to fulfill the following objectives:

- 1) Determine the extent of the DKM *U-166* wreck site
- 2) Collect high-definition video of the wreck sections and artifact field
- 3) Photo-document the visible wreck sections, artifacts, and relevant biological communities
- 4) Acoustically position visible wreck sections and artifacts
- 5) Deploy long-term and short-term microbiological experiments
- 6) Collect biological samples (rusticles) from the wreck site

DESCRIPTION: Between October 5 and 10, 2003 investigations were undertaken from the NOAA ship R/V *Ronald H. Brown* to document the wreck site of the DKM *U-166* using a remotely operated vehicle (ROV). This project represented the deepest archaeological investigation conducted to date in the Gulf of Mexico. It also marked one of the first times that positioning technology that is standard in the offshore oil and gas industry was utilized for an archaeological investigation.

The wreck of the DKM *U-166* is located in the Mississippi Canyon Block Area in the Gulf of Mexico. Water depth at the wreck site is approximately 5,000 feet. Sediments at the wreck site consist of greenish-gray silt and clay. Overall the seafloor around the wreck site is relatively flat and even although areas of low sediment mounds are present around the stern section of the wreck.

The DKM *U-166* wreck site can be divided into three distinct areas - the stern hull remains, the bow remains, and the debris field. The stern remains consist of approximately 200 feet of the vessel's hull from the stern to several feet past the forward deck gun. The bow section, which lies nearly 500 feet away to the west, is an approximately 55-foot section of the vessel consisting of part of the forward hull and bow that broke away from the main section of hull. The debris field extends between and to the south of the two sections of hull. It consists of a dense scatter of material from the interior and the exterior of the U-boat.

The 2003 field investigation of the DKM *U-166* focused on documenting these three areas. Field investigations began on 5 October 2003. After transiting from Gulfport, Mississippi to the wreck site location, the Ronald Brown took position over the wreck to begin operations. The first task was the deployment of the acoustic beacons (compatts) which made up the long baseline positioning system. Over a period of roughly 18 hours, five compatts were deployed in a 2,296-foot diameter array around the wreck site. Once placed on the seafloor, the beacons were calibrated to ensure positioning was within acceptable accuracy levels.. After the beacons had been calibrated documentation of the wreck commenced. The first phase of the documentation was to produce a photo mosaic of the hull remains. Work on the photo mosaic was started at the bow section. The ROV followed a series of predetermined lines over the bow section while digital still images were taken approximately every 10 feet along the hull and digital video imagery was collected. Once the bow section had been documented the short and long term microbiological experiments were placed on the bow. The photo mosaic process was then repeated on the stern section and the microbiological experiments placed on that section of the wreck site.

Once the photo documentation of the hull remains was complete, a survey of the entire wreck site commenced. The ROV traversed a predesignated grid of 63 north-south survey lines spaced 10 feet apart while collecting continuous digital video imagery. The ROV's altitude during the survey ranged from between 6 to 15 feet above the seafloor. As the ROV moved down each survey trackline, observers in the ROV control room watched the video from the ROV's cameras on monitors. When a section of the wreck or other artifacts were noted, the ROV came to a hover over the object, digital still images were taken, and a position fix was acquired. This information was then entered onto an artifact information log and the survey resumed. Survey of the debris field continued until the late afternoon of October 9, 2003 at which time the originally planned 63 survey lines were completed. ROV operations on the DKM *U-166* site were then temporarily halted to allow an additional survey of the DKM *U-166* site with the HUGIN 3000 AUV. During the next roughly 9.5 hours while the HUGIN 3000 conducted a survey of the DKM *U-166*, the R/V *Ronald Brown* transited approximately a mile to the west to allow an investigation of the S.S. *Robert E. Lee* to be carried out using the ROV. The investigation of the S.S. *Robert E. Lee* identified several sonar targets that had not been investigated in 2001, collected digital video imagery and still images of the wreck remains, and collected samples of rusticle colonies from the wreck for study.

Early on the morning of 10 October, following the completion of the HUGIN 3000 AUV survey, the R/V *Ronald Brown* returned to station over the DKM *U-166* wreck site and the ROV resumed

the documentation of the debris field. The debris field was determined to extend beyond the southern extent of the original survey area and it was decided that additional lines would be surveyed as time permitted to attempt to locate the southern edge of the debris scatter. Prior to running the additional lines, rusticle samples from the DKM *U-166* were taken from the conning tower under the guidance of NOAA OE and Mineral Management Service representatives and the short term microbiological experiments were also recovered. The additional survey to locate the southern boundary of the debris field began early on the morning of October 10 and continued until approximately noon before deteriorating weather conditions and time constraints force the investigations at the site to be suspended. Five additional east-west lines approximately 540 feet in length spaced 30 feet apart were surveyed to the south of the original survey area, but the southern extent of the debris scatter was not located.

Following the termination of the wreck site investigations the ROV and the compact beacons were recovered and brought on board the R/V *Ronald H. Brown*. Once the ROV and other equipment had been secured the R/V *Ronald H. Brown* began transiting to the Port of Pensacola, Florida where it arrived on the morning of 11 October 2003.

ANALYSIS OF OBJECTIVES: The goal of the 2003 Field Investigations on the DKM *U-166* wreck site was to achieve the six objectives listed above. With the exception of one, all the objectives were fully completed. The following is a detailed discussion of each objective and whether it was successful or not.

1) Determine the extent of the DKM *U-166* wreck site

Of the six objectives, determining the DKM *U-166* wreck site boundaries was the only objective that was only partially completed. The determination of the site limits is important to understanding the site distribution and formation. It will also assist in developing a nomination to the National Register of Historic Places, or as a National Battlefield Site. Using information from the 2001 AUV and ROV investigations a standard archaeological survey grid consisting of 63 parallel survey lines covering an area of approximately 945 x 600 feet. Based on the available data, the debris field was considered to be light to moderate and was not expected to extend beyond the coverage area.

During the 2003 field investigations, the ROV completed the survey of the entire 945 x 600 feet survey area. This survey determined the northern, eastern and western extents of the wreck site, but indicated the southern edge extended beyond the planned survey area. Additional lines were surveyed in an effort to find the southern end of the debris field. Five additional east-west lines were surveyed out to approximately 93 feet south of the southern edge of the original survey area before weather and time constraints forced an end to the seafloor investigations. Each line was approximately 540 feet in length spaced 30 feet apart. The data from the additional lines indicated that the debris field continues further to the south. Additional survey work is planned for the 2004 field season to locate the southern boundary of the wreck site.

There are several reasons that this objective was only partially completed. First, the density of the debris field was much heavier than expected. The 2001 data used to plan the 2003 survey indicated a light to moderate density of material (artifacts) in the debris field, when it was actually a heavy density. This required more time than originally estimated to document the numerous artifacts within the debris field, leaving less time for additional survey.

Second, equipment malfunctions increased the time necessary to document each artifact or groups of artifacts. Initially a dual parallel laser measuring system was to be utilized to measure artifacts. Prior to the commencement of this cruise the single unit on the R/V *Ronald Brown* failed and could not be replaced. This required that an alternative method of measurement be developed and used. This system use a two-foot metal straight edge scale marked with six-inch division marks. This scale stick was extended using the ROV's manipulator arm to measure an artifact. Measuring each artifact located using this system also increased the time necessary to document artifacts in the debris field and leaving less time for additional survey.

Finally, the HUGIN 3000 AUV survey and deteriorating weather conditions also contributed to only partial completion of this objective. The HUGIN 3000 AUV was scheduled to conduct a high-resolution remote sensing survey of the DKM *U-166* site in conjunction with the ROV investigations. It was estimated that approximately 8 hours would be needed for the AUV to complete the survey for both the S.S. *Robert E. Lee* and the DKM *U-166* sites; however, the AUV was on location at the DKM *U-166* site for approximately 9.5 hours. During this time, the ROV was utilized to investigate the S.S. *Robert E. Lee* site and several previously unidentified targets to the south of the S.S. *Robert L. Lee*. After the AUV completed its survey, ROV operations resumed on the DKM *U-166* site, but poor weather conditions moved in faster than expected forced a halt to survey operations several hours earlier than initially planned due to safety concerns.

Despite the fact that the southern extent of wreck site was not located, the survey itself can be considered a success. Approximately 718,760 square feet or 16.5 acres of seafloor was surveyed at a water depth of 5,000 feet. This represents the deepest and most detailed survey of a shipwreck site conducted in the Gulf of Mexico.

2) Collect High Definition Video of the Wreck Sections and Artifact field

The objective to collect high definition video imagery of the DKM *U-166* wreck site was successful. The collection of this video is important to further study of the site. Because of the inaccessibility of the site, detailed video documentation is necessary to allow future study of the site by other interested scientists. To provide the highest definition imagery possible a three chip digital video camera was used. During the project approximately 58 hours or 200 gigabytes of digital video imagery was collected on mini-digital videotape and on DVD. This imagery details the hull remains of the DKM *U-166* and the S.S. *Robert E. Lee*, the artifact remains located in the debris field, biological aspects of the wreck site, and bottom topography at the site.

3) Photo-document the visible wreck sections, artifacts, and relevant biological communities

The objective to photo-document the archaeological and biological aspects was successful. Still digital photographs were taken of the main hull remains, individual or groups of artifacts, and biological communities. This included a photo mosaic of the bow and stern sections (the mosaic is still being assembled), as well as still images of specific sections of the hull remains and 307 individual or groups of artifacts. Approximately 1800 still digital images were collected during the project. These images are currently being analyzed, cataloged, and placed into a database.

4) **Acoustically position visible wreck sections and artifacts**

The objective to provide real world locations for the hull remains and artifacts located at the wreck site was successful. Accurate positioning of wreck site debris is important to the study of the site formation process and to the study of artifact distribution and patterning at the site. To achieve this object a Sonardyne Fusion Long Baseline (LBL) or range-range acoustic measurement system was used. This system uses transponders placed at known locations on the seafloor to calculate the position of the transceivers mounted on the ship and/or ROV. During the 2003 DKM *U-166* field investigations five medium frequency COMPATT transponder beacons were deployed in a 2,296 foot diameter array around the site. Once these beacons had been calibrated the overall positioning accuracy was within 1 foot in 5,000 feet of water.

The LBL positioning system was used to provide position information on the ROV as it surveyed the site (Sheet 1). It also provided one of the highest accuracies for artifact positioning achieved on an archaeological site survey at this depth. Using the LBL positioning system 307 individual artifacts or groups of artifacts were located and real world coordinates obtained for them (See Sheet 2). The digital images and coordinates of each artifact are currently being correlated and placed into an artifact database.

5) **Deploy long-term and short-term microbiological experiments**

The objective to deploy long and short term microbiological experiments on the wreck of the DKM *U-166* was successful. Two IPSCO long term test platforms were deployed, one on the bow and one on the stern wreckage. These platforms provide data on the structural degradation of the wreck over time. Additionally short-term Biological Activity Reaction Tests (BARTS) and Etch tests were placed at various locations on the bow and stern hull structures. These tests provide information on what types of bacterial communities on the wreck and the level of bacterial activity at the site. At the conclusion of the 2003 field investigations, the BARTS and Etch tests were recovered from the seafloor for analysis. The IPSCO test platforms were left in place. They will be monitored during subsequent visits to the wreck site.

6) **Collect biological samples (rusticles) from the wreck site**

The objective to collect rusticle samples from the DKM *U-166* wreck site was successful. Samples of rusticles from the DKM *U-166* were obtained from the area of the conning tower. The rusticles on the DKM *U-166* were noted to be white in coloration. This type of rusticle has only been previously observed on the wreck of the German Battleship DMK *Bismarck*. In addition to the rusticles obtained from the DKM *U-166*, rusticle samples were also gathered from the site of the S.S. *Robert E. Lee*. All rusticle samples were brought to the surface where preliminary analysis was carried out. Following the field investigations the rusticles were transported to Droycon Bioconcepts, Inc. in Regina, Saskatchewan, Canada where further analysis is being carried out.

SIGNIFICANT CONCLUSIONS: The digital data and biological samples collected during the DKM *U-166* are still undergoing compilation and analysis. It is possible, however, to make preliminary summary comments based on available information. This summary, presented below in point form, is preliminary in scope and subject to change as a result of further analysis and interpretation.

Preliminary Archaeological Findings

- (1) As noted during the 2001 investigation, the DKM *U-166* site consists of two main sections of hull remains - an approximately 200-foot section that extends from the stern to just past the forward gun and an approximately 55-foot section of the bow, which has separated from the rest of the hull and rests roughly 500 feet to the west. No other significant sections of hull remains were noted during the 2003 survey.
- (2) Between the two sections of hull remains and extending to the south is a dense debris field containing materials from both the interior and exterior of the u-boat.
- (3) Based on the field information, the northern and westernmost boundaries of the site are just past the remains of the bow section. The easternmost boundary of the appears to be just east of the stern and conning tower.
- (4) The heaviest concentration of artifact material in the debris field is located in the western area of the site near the bow debris. Preliminary interpretation of the density of the material and the artifact distribution suggests the bow may have broken up closer to the seafloor and that the vessel did not implode. This would support the hypothesis that the depth charge from *PC-566* ruptured the pressure hull causing the U-boat to fill with water and as the vessel approached the seafloor an internal explosion of unknown origin possibly occurred causing the bow section to be torn away from the rest of the vessel.

Preliminary Microbiological Findings

- (1) Considerable differences were observed in 2003 between the rusticles found on the S.S. *Robert E. Lee* and DKM *U-166*. These differences related to the dominant metal content that was iron in the rusticles of DKM *U-166* and aluminum in the S.S. *Robert E. Lee*.
- (2) Both the S.S., *Robert E. Lee* and DKM *U-166* had strontium in the rusticles that was at least one order of magnitude higher than that recovered from rusticles that had grown on the HMHS *Britannic*.
- (3) Microbiologically the DKM *U-166* site was rich in both bacterial and fungal activity with very aggressive proteolytic activity being observed using the etching technique.



307

608

302

SHIPWRECK
(U-166)
"Bow"

SHIPWRECK
(U-166)
"Stern"

SURVEY AREA

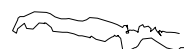
306

101

LEGEND



101 COMPATT LOCATION WITH REFERENCE NUMBER



ROV TRACKLINE

Preliminary

SHEET 1

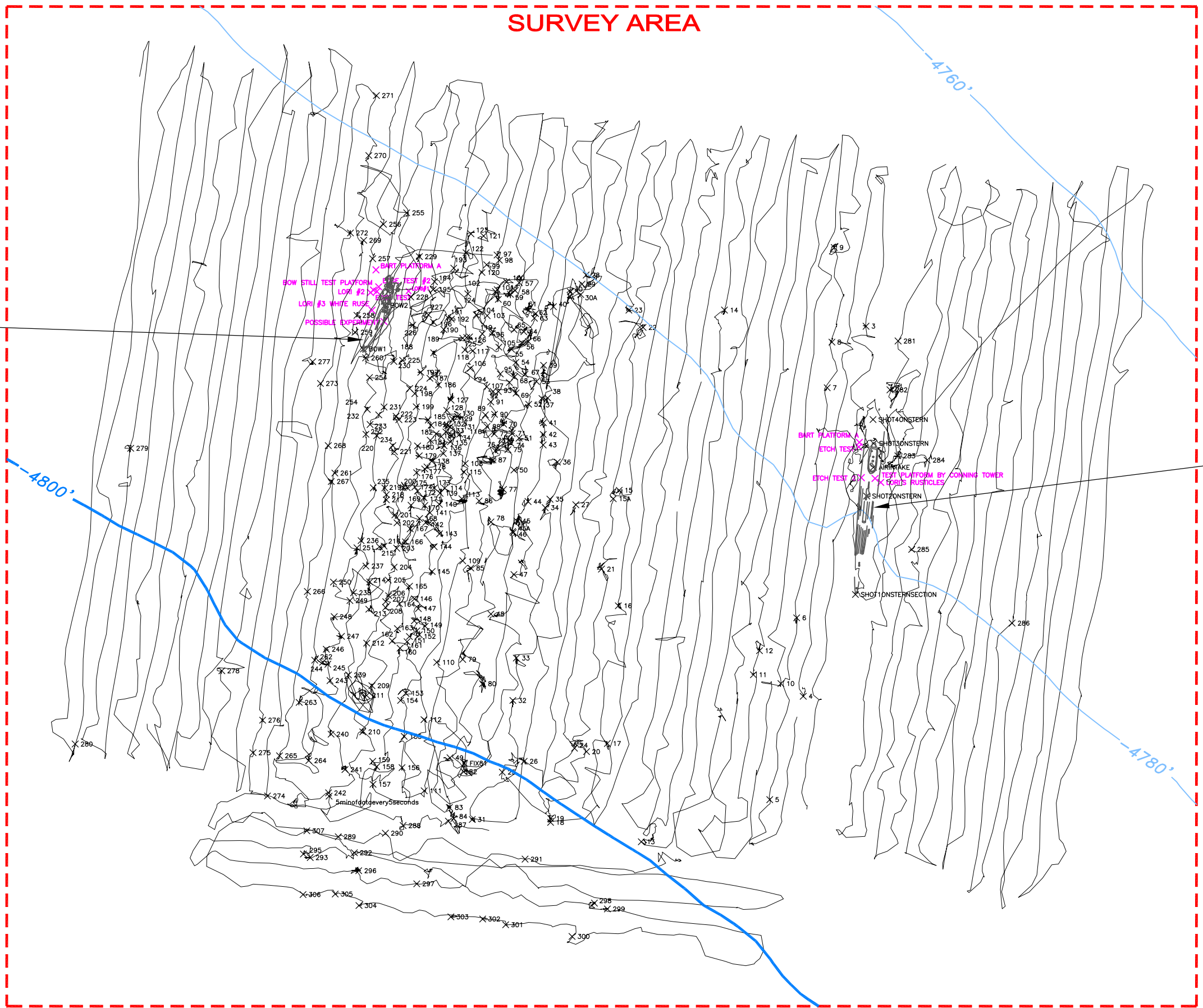
U-166 INVESTIGATIONS ROV TRACKLINES MAP



SURVEY AREA

SHIPWRECK
(U-166)
"Bow"

SHIPWRECK
(U-166)
"Stern"



LEGEND

× 279	ARTIFACT LOCATION WITH REFERENCE NUMBER/DESCRIPTION
× RUSTICLE	BIO EXPERIMENT LOCATION WITH DESCRIPTION

Preliminary

SHEET 2
ARTIFACT DISTRIBUTION MAP

